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Implementation of Outcome-Based Education System in Engineering Education using Real-Time Application

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Abstract: In recent years, worldwide educational institutions especially engineering and technical institutes observed a lack in the traditional education system which has many limitations regarding the assessment of technical knowledge and skills of the engineers. In the context of the above-mentioned issue Outcome-Based Education (OBE) model was specified by Washington Accord (WA) which involves the assessment and evaluation process in engineering education to demonstrate the quality of graduates by measuring their performance and technical skills. The manual record-keeping cannot extract meaningful information about these skills and qualities. Therefore, the Pakistan Engineering Council (PEC) is trying to implement the OBE system in all accredited Degree Awarding Institutes (DAIs) of Pakistan. In this paper, we designed a real-time application based on Microsoft excel for the assessment and evaluation of student performance at the undergraduate level. In this application, the mapping of Course Learning Outcomes (CLOs), as well as Program Learning Outcomes (PLOs), has been designed according to course contents. Self-assessment reports of both student and teacher are prepared after analyzing student's performance and teacher's contributions respectively. This paper also proposes the easy usage of the OBE system with the results and the case study courses described for the better attainment of CLOs and PLOs.

Keywords: Outcome Based Education; Program Learning Outcome; Course Learning Outcome;

I. INTRODUCTION

In today's era, the education system has different models depending upon teaching techniques, styles, and learning assessments. These models illustrate the teaching style by defining various ways of teaching methodologies presented in Figure 1. These methodologies and learning assessments help to improve conceptual learning approaches of the education system [1]. Traditional or conventional education model (TEM) based on a teacher-centered system, which depends on the subject-based study and daily basis lectures are delivered to students on prescribed topics [2]. Progressive education model (PEM) employs practical concepts rather than theoretical knowledge and focuses on experience over formal learning [3]. Competency-based education (CBE) illustrates the master-level expertise of students in a specific domain and has efficient communication and technical skills in the teaching profession [4,5]. Outcome-based education (OBE) depends upon the student-centered system by defining different outcomes or goals that will be achieved by each student at the end of the specific course and program [6]. Furthermore, it has special assessment techniques that precisely realize skills, concepts and professional approach to the prescribed domain [7]. For the implementation of the OBE system in engineering education there are components that should be mainly kept in mind like vision, mission, course learning outcomes (CLOs), program learning outcomes (PLOs) and program education objectives (PEOs) [8].

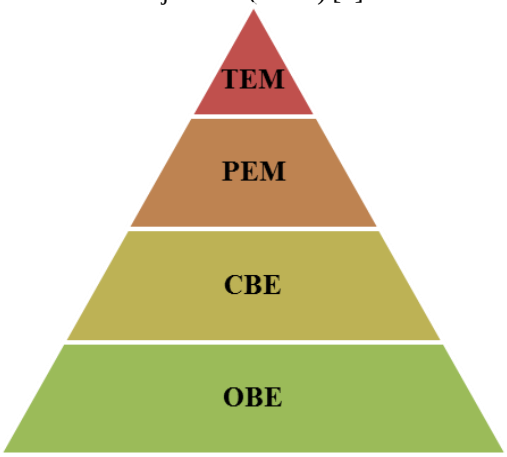


Figure 1: Educational models.

II. OUTCOME BASED EDUCATION

The latest reforms in the engineering education system are the main priorities of different educational and technical institutions around the world. Engineering graduates are increasing day by day nationally and internationally in various specializations and domains. So, there should be a central quality assurance mechanism that assesses and verify

professional and technical expertise in graduates. Almost every multinational company employs recruitment criteria to check the suitability of candidates having hands-on skills like communication, leadership, intelligence, problem-solving expertise and team working competencies [9]. In this perspective, the OBE system is the mainframe for the assurance of continuous quality control in engineering education to improve technical education [10]. According to international educational researchers, better and finest results have been recorded after the implementation of the OBE system in engineering education. In current educational scenario, the OBE system has remarkable importance in the technical field due to continuous quality improvement [11]. Therefore, the majority of engineering institutions worldwide approved to implement the OBE system in their academic curriculum for the employment of advanced education and learning techniques. Figure 2 illustrates those countries that have implemented the OBE system [12].

Figure 2: Countries employed Outcome Based Education System [12]

Pakistan Engineering Council (PEC), Pakistan, is the core organizational body of the Government of Pakistan to accredit engineering degree awarding institutes, technical programs and ensure the quality of institutes and graduates according to international standards through Washington accord (WA). The main objective of maintaining these standards to make equivalent engineering graduates of developing countries to the developed countries by implementing the OBE system [13]. This can only be possible when all the course and program outcomes or goals are the same. Therefore, the OBE system gives us a platform where all the CLOs and PLOs are pre-defined for better assessment on the same scale.

In the 1950s, Bloom developed taxonomies which became the benchmarks in the evaluation and formulation of the outcomes. Mead and Bennett depict the assessment criteria of learning outcomes based on Bloom's taxonomy. Bloom's working provides us with six successive levels arranged in the hierarchy as shown in Figure 3 [13].

The PLOs of a particular program are defined and approved by the program advisory committee including head of institutes and industrial experts. Similarly, CLOs of a specific course in the prescribed program are defined by faculty members of the institute and finally approved by the program advisory committee.

These CLOs and PLOs have great relation for the assessment of goals achievement by each student of the prescribed program. In OBE, a student should have a better understanding of their course and program outcomes [14].

In this system, average marks are calculated for the evaluation of student performance in a specific course. The course learning outcomes of a course should be mapped on one or more program learning outcomes of that discipline [15].

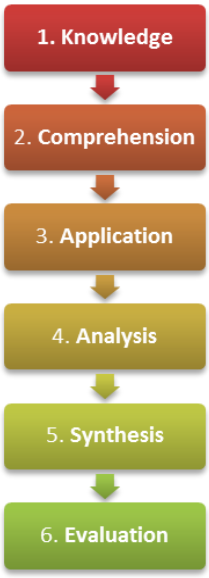


Figure 3: Bloom's Taxonomy learning & assessment hierarchy [13]

PLOs can be further mapped on program educational objectives described by graduated students or alumni of that program for better implementation [16-18]. The effectiveness of the OBE system can be analyzed by assessing the behavior of a student in different assignments, quizzes, and exams. This process of quantification repeatedly employed for the whole duration of that program until graduation of students [19,20]. Students graduating under the OBE system have not only technical knowledge of the prescribed program but they have also globally accepted expertise in different skills [21,22].

In the OBE system rather than the traditional education model, firstly it checks curriculum design by higher education, and then faculty members of the institutes declare the content of the syllabi for the achievement of specific course learning outcomes in light of program learning outcomes. Finally, different methods or techniques are used to assess the skills and technical abilities of students as presented in Figure 4 [23]. Therefore for the successful implementation of OBE, these are major steps:

i. Course Outline Description
ii. Curriculum design
iii. Content declaration
iv. CLO-PLO Mapping
v. Assessment techniques

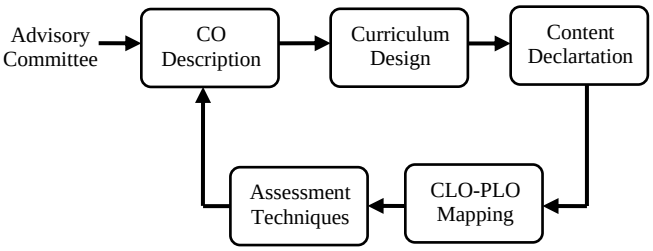


Figure 4: Successful implementation of OBE System [23]

III. COURSE LEARNING OUTCOMES

At the start of each academic session, different courses are allotted to the instructors according to their specific field or domain. Each instructor or faculty member defines CLOs depending upon field relevancy and benefit of the specified course. According to the course curriculum, many books of different authors are recommended by the higher education commission (HEC) in the syllabus. Faculty member describes CLOs after studying and analyzing the preface of these books. After graduation, these students have to apply their technical knowledge in the industry or research work, therefore, CLOs have significant importance in the OBE system [10]. Finally, these CLOs are mapped on pre-defined PLOs. The CLO-PLO mapping is divided into three levels: 1 (Full), 0.5 (Half) and blank (0) in this research work but according to weightage factor it can be varied from 0-1 e.g 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1. If the prescribed course has three CLOs and twelve PLOs, then each CLO can be mapped with all the PLOs individually. If the CLO has a direct relation with any PLO then it is mapped as 1, if it has less relation then 0.5 and if the CLO has no relation with PLO then the mapping is to be left blank. As already cited above, finally, the CLO-PLO mapping is discussed with all faculty members, head of the department and industrial representative for final approval. Table 1 represents course learning outcomes of "Electrical Network Analysis" a course in the undergraduate program of Electrical Engineering.

TABLE 1: CLOS OF ELECTRICAL NETWORK ANALYSIS COURSE

CLO 1	Elaborate the effect of power transfer, power dissipation and power factor on power transmission
CLO 2	Analyze RLC circuits and differentiate between Transient and Steady-State responses
CLO 3	Formulate Time domain, Phasor and Frequency domain response of second-order circuits

IV. PROGRAM LEARNING OUTCOMES

These are the PLOs of Engineering department:

PLO 01: Engineering Knowledge
PLO 02: Problem Analysis
PLO 03: Design/Development of Solutions
PLO 04: Investigation
PLO 05: Modern Tool Usage
PLO 06: The Engineer and Society
PLO 07: Environment and Sustainability
PLO 08: Ethics
PLO 09: Individual and Team Work
PLO 10: Communication
PLO 11: Project Management
PLO 12: Lifelong Learning

V. WORKING PRINCIPAL OF APPLICATION

First of all, the course instructor should have to map CLOs against PLOs according to syllabus distribution in session wise breakdown, then put weightage from 0 to 1 against assignment No. 1 to 5, quiz No. 1 to 5, midterm exam and final term exam as presented in Figure 5.

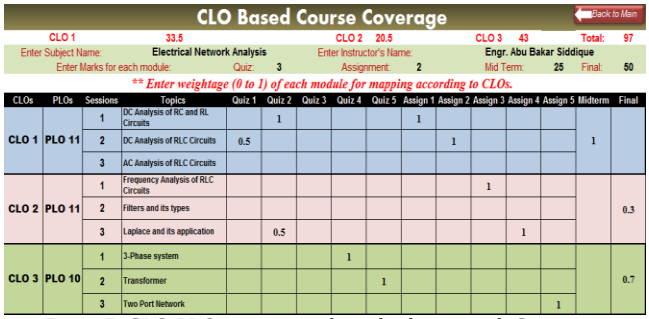


Figure 5: CLO-PLO mapping with marks density with Course *Coverage*

Then weightage inserted against each module of a single CLO will be summed up and automatically inserted against mapped PLO. Similarly, for better visual results this application will automatically generate a graph of CLO-PLO mapping with marks density as shown in Figure 6. This marks the density of above cited three CLOs will be equal to the total marks of that course. The result sheet will use these weightage factors for further calculations to observe the final response of each student.

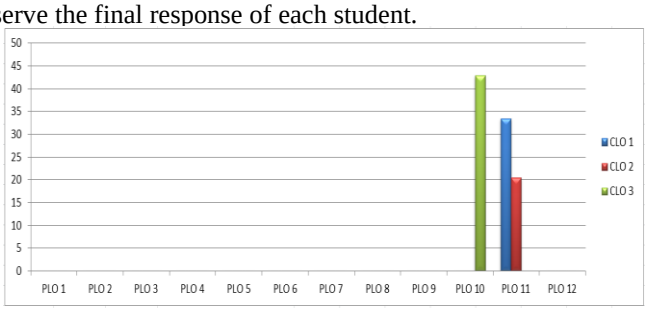


Figure 6: Graph of CLO-PLO mapping with marks density

Secondly, the course instructor will put marks of each student against his/her roll number in the result sheet gradually with respect to assignments, quizzes and exams are taken. This result sheet will calculate marks based on the mapping of each module against CLOs and express in the result sheet as well as for individual student's Detailed Marks Sheet (DMC) as illustrated in Figure 7. If a student failed to submit any assignment or take part in any quiz or exam then 0 marks will be considered.

RESULT SHEET

CLO 1: 33.5 CLO 2: 20.5 CLO 3: 43 Total: 97

Roll No.	Name	QUIZ 1	QUIZ 2	QUIZ 3	QUIZ 4	QUIZ 5	ASSIGN 1	ASSIGN 2	ASSIGN 3	ASSIGN 4	ASSIGN 5	MID	FINAL	CLO 1	CLO 2	CLO 3
Marks of Each Module >>		3	3	3	3	3	2	2	2	2	2	25	50	33.5	20.5	43
BAEM-F17-001	MABEER	3	3	3	3	3	2	2	2	2	2	25	50	100	100	100
BAEM-F17-003	MUHAMMAD ABDULLAH	3	3	3	3	3	2	2	2	2	2	25	50	100	100	100
BAEM-F17-004	MOAZ AHMAD	1	0	1.2	1.5	1.2	1.6	1.2	1	1.2	1.2	21.5	32.6	74	58	62
BAEM-F17-007	SALMAN YAHYA	0	2.1	0	1	1	1.2	1	1.6	1.4	1.4	17	27.7	64	60	53
BAEM-F17-008	HAFIZ FAROOQ AHMED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BAEM-F17-011	AMEED RAZA	0	1.5	1.8	1.2	0	2	1.6	1.2	1.2	1.2	15	26.7	60	54	45
BAEM-F17-012	SYED ZAIN ABBAS	3	3	3	3	3	2	2	2	2	2	25	50	100	100	100
BAEM-F17-013	ALI AHMAD	0.6	0.6	0	0	0	1	0.8	1.6	2	2	13	21.6	47	51	40
BAEM-F17-015	ARSLAN ALI	1.8	3	1.2	1.2	1.5	1.6	2	1.6	1.6	1.6	17.5	34.6	75	74	66
BAEM-F17-016	MUHAMMAD SAQIB KHALIL	0	0	0	0	0	0	0	0	0	0	15.5	16.5	46	23	25
BAEM-F17-018	MUHAMMAD AHMAD KHAN	0	0	0	0.6	1	1	1	1	0	0	12.5	17.1	43	30	32
BAEM-F17-019	MUHAMMAD SHARIF YOUNUS	0	1.5	1.2	2.1	0	2	2	1.6	1	1	15.5	27.9	63	57	53
BAEM-F17-020	SADIA	1	1.2	1.2	2.1	0.5	2	1.6	1.6	1	1	15.5	28.7	62	58	55
BAEM-F17-021	ZAIN-UL-ABDEEN	3	2.1	3	2.1	1.8	2	1.6	1.6	1.6	1.6	23.5	43.9	92	85	84
BAEM-F17-022	REHAN NOOR	0	1	0	2.1	1.2	1	1	2	1	1	17.5	27.8	61	58	55
BAEM-F17-024	FAISAL SHOUKAT ALI	1.8	1.8	1.2	2.4	3	2	1.6	1.6	1.6	1.6	21.5	40.1	83	79	82
BAEM-F17-023	MUMAR HASSAN	0	0	0	2.5	0.8	2	1.6	1.6	1.6	1.6	19	33	67	64	65
BAEM-F17-009	MUHAMMAD HAMZA	1.8	1.8	1.2	1.5	1.8	2	1.6	1.6	1.6	1.6	22.5	37.2	86	74	72
														0	0	0

Figure 7: Result Sheet of Electrical Network Analysis Class

VI. ALGORITHM

The process of the OBE system operates during the whole session or semester including all modules like assignments, quizzes, midterm, and final term examinations. It considers all assessment tools from course allocation to end the semester as illustrated in Figure 8. In the mapping of CLOs, all the modules are included with specific content weightage approved by the advisory committee of the institution. In this application, the results of each student during the semester express complete behavior to the instructor. In this way, the instructor can see weak points of each student during the semester and make some decisions to improve their level of understanding and learning by varying teaching methodology etc. After course allocation, CLOs will be declared and mapped according to the subject contents. Weightage factor for each module will be inserted in front of each CLO. Marks of each module will be entered in the result sheet of the whole class. The result sheet will calculate session wise marks to represent specified CLO. The internal assessment of OBE mainly depends on three factors i.e CLOs-PLOs average, the population density of students for CLOs and self-assessment reports. These factors play a much important role in maintaining continuous quality improvement of the education system.

This application also identifies weaknesses of the module while analyzing the response of students and teacher by generating teacher evaluation Performa in order to get to get precise information about teacher's class behavior, teaching methodology and technical grip on specific topic as illustrated in figure 9. To maintain continuous quality (CQI) it declares some suggestions by generating Self Assessment Reports of students as well as teachers.

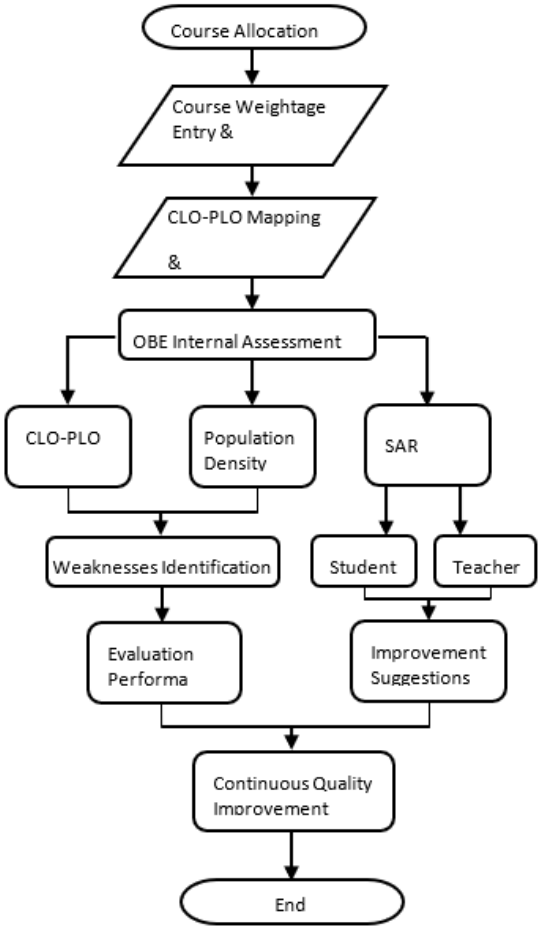


Figure 8: Outcome-Based Education Algorithm

Teacher Evaluation Performa Back to Main

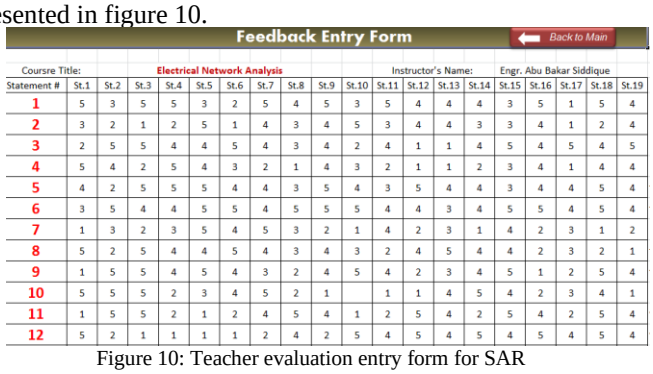
Coursre Title: Electrical Network Analysis
Instructor's Name: Engr. Abu Bakar Siddique
Evaluation Criteria: 60

***For each statement please indicate your level of agreement by writing a score between 1 to 5. A higher score indicates stronger agreement with the statement.*

Statement #	Statement	Score
1	Is teacher prepared for class and knows his/her subject?	
2	Teacher is clear in giving directions and on explaining what is expected on assignments and quizzes.	
3	Teacher is flexible in accomodating for individual student needs.	
Course Content		
DC Analysis of RC and RL Circuits		
4	Teacher dilevered and communicated well about above mentioned topic?	
5	Does teacher covered above mentioned topic in appropriate time by possessing deep knowledge?	
6	Is the above mentioned topic tough to understand?	
DC Analysis of RLC Circuits		
7	Teacher dilevered and communicated well about above mentioned topic?	
8	Does teacher covered above mentioned topic in appropriate time by possessing deep knowledge?	
9	Is the above mentioned topic tough to understand?	

Figure 9: Teacher Evaluation Performa / Student's Feedback

Students have to give a score between 1 to 5 according to their agreement with the statement of feedback form. After getting the evaluation performa from each student of the class it should be entered in the following entry form to evaluate teacher's performance for the prescribed subject as presented in figure 10.



Statement #	St.1	St.2	St.3	St.4	St.5	St.6	St.7	St.8	St.9	St.10	St.11	St.12	St.13	St.14	St.15	St.16	St.17	St.18	St.19
1	5	3	5	5	3	2	5	4	5	3	5	4	4	4	3	5	1	5	4
2	3	2	1	2	5	1	4	3	4	5	3	4	4	3	3	4	1	2	4
3	2	5	5	4	4	5	4	3	4	2	4	1	1	4	5	4	5	4	5
4	5	4	2	5	4	3	2	1	4	3	2	1	1	2	3	4	1	4	4
5	4	2	5	5	5	4	4	3	5	4	3	5	4	4	3	4	4	5	4
6	3	5	4	4	5	5	4	5	5	5	4	4	3	4	5	5	4	5	4
7	1	3	2	3	5	4	5	3	2	1	4	2	3	1	4	2	3	1	2
8	5	2	5	4	4	5	4	3	4	3	2	4	5	4	4	2	3	2	1
9	1	5	5	4	5	4	3	2	4	5	4	2	3	4	5	1	2	5	4
10	5	5	5	2	3	4	5	2	1		1	1	4	5	4	2	3	4	1
11	1	5	5	2	1	2	4	5	4	1	2	5	4	2	5	4	2	5	4
12	5	2	1	1	1	1	2	4	2	5	4	5	4	5	4	5	4	5	4

Figure 10: Teacher evaluation entry form for SAR

VII. RESULTS

The main objective of this application is to demonstrate and identify the weaknesses of students in their learning aspects as well as maintain continuous quality improvement in academia. First of all, the dashboard of the application presents individual student behavior against each CLO with a graphical representation of session wise marks detail as illustrated in Figure 11. To see whole class achievement regarding each CLO in the form of the graph can be presented as Figure 12.

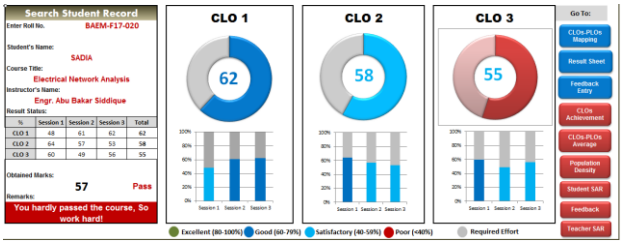


Figure 11: Individual student assessment dashboard

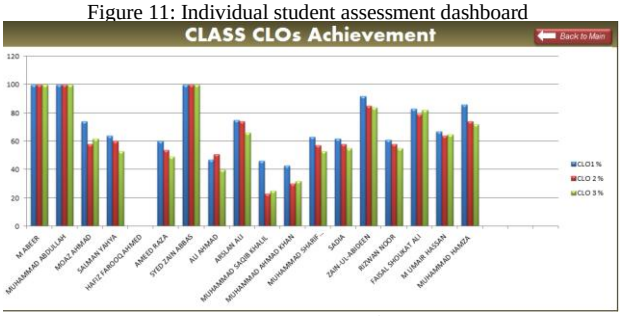


Figure 12: CLOs achievement of the whole class

Similarly, the performance of the whole class can also be assessed in CLOs-PLOs average achievement block as illustrated in Figure 13.

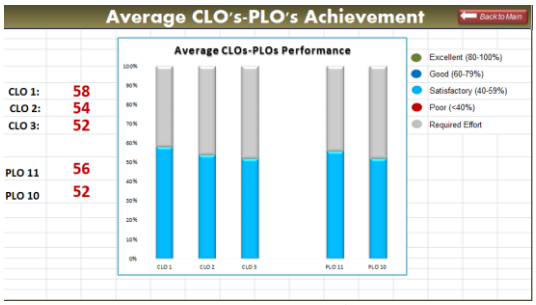


Figure 13: CLOs & PLOs average performance in the class

Figure 14 represents the percentage of the population of students in a class according to their performance in each CLO by demonstrating the result as excellent as green color, good as blue color, satisfactory as cyan color and poor as red color.

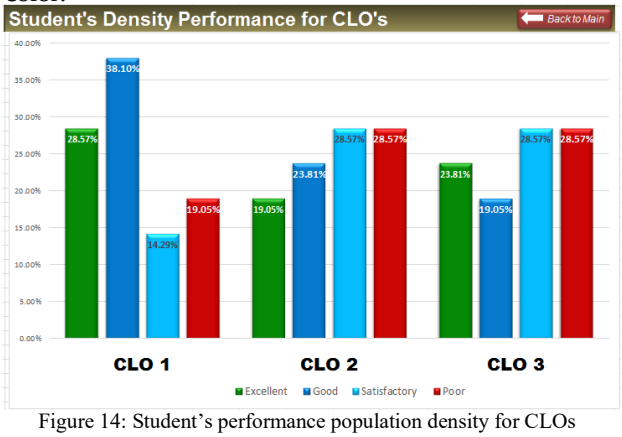


Figure 14: Student's performance population density for CLOs

Student SAR presents achieved goal of each student according to CLO and also suggest a revision of the same topic in which student's performance is less than the required criteria as illustrated in Figure 15.

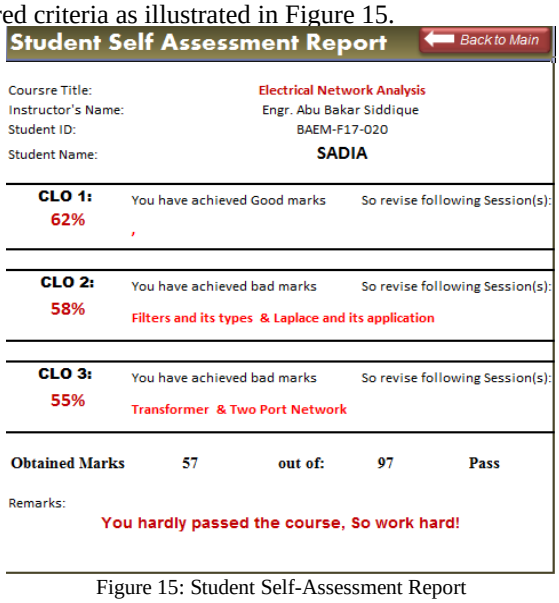


Figure 15: Student Self-Assessment Report

Teacher SAR demonstrates the effectiveness of a course instructor in that session in which students have performed bad or achieved fewer marks. In this course, students got fewer marks in three topics as mentioned in Figure 16.

Teacher SAR will give remarks according to the feedback given by students in the evaluation performance. There are three constraints on teacher evaluation which depend upon Communication & methodology, time is given to the topic and topic's flexibility. In this course, a 58% score has been achieved against communication & methodology, which is much lower than expected criteria so, SAR recommended the suggestion to change teaching methodology for better results in the future.

Teacher Self Assessment Report ← Back to Main

Coursre Title:	Electrical Network Analysis
Instructor's Name:	Engr. Abu Bakar Siddique

These results represent behavioral analysis of student's feedback.

Teacher's Behaviour:	71.58%	* Your calssroom behavior is not satisfactory, Kindly improve it

Session	Communication & Methodology	Time	Tough
DC Analysis of RC and RL Circuits	58%	81%	87%
DC Analysis of RLC Circuits	54%	69%	72%
Frequency Analysis of RLC Circuits	63%	66%	67%
Recommendations	58%	72%	75%

Suggesstions

* You should have to change your teaching method as students could't attain maximum knowledge by your delivery methodology.
* It seems you did't gave appropriate time to the prescribed sessions, so consider it for better results.

Figure 16: Teacher Self-Assessment Report

VIII. Conclusion

In this paper, a real-time application based on Microsoft excel has been designed to implement outcome-based education in engineering institutes to assess the abilities of each individual by measuring their performance and technical skills. The mapping of CLOs, as well as PLOs, has been designed according to course contents. Self-assessment reports of both student and teacher are prepared after analyzing student's performance and teacher's contributions respectively. This paper also proposes the easy usage of the OBE system with the results and the case study courses described for the better attainment of CLOs and PLOs.

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